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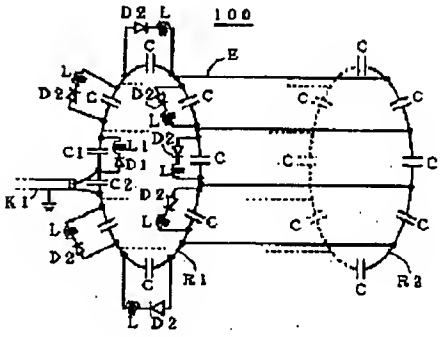
(54) BIRDCAGE COIL FOR MRI

(57) Abstract:

PURPOSE: To provide a birdcage coil for MRI which can certainly decouple another coil and of which circuit construction is simplified without deteriorating the inherent coil characteristics.

CONSTITUTION: A number of elements E are interposed between a first ring R1 and a second ring R2. A capacitor series circuit of a first capacitor C1 and a second capacitor C2 is interposed between the first ring R1 and one of the connecting points of a plurality of element E. A series circuit of a first inductor L1 and a first diode D1 is connected to the first capacitor C1 in parallel. The inductance of the first inductor L1 is determined so that a parallel resonance frequency is almost equal to an RF pulse for MRI. A third capacitor C is interposed between the first ring R1 and another one of the connecting points of the elements E. A series circuit of a second inductor L and a second diode D2 whose direction is the same as that of the first diode D1 is connected to the third capacitor C in parallel. The inductance of the second inductor L is determined so that the parallel resonance frequency is almost equal to the frequency of the RF pulse for MRI.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the birdcage coil for MRI which can turn the function as a coil on and off electrically from the outside in more detail about the birdcage coil for MRI (Magnetic Resonance Imaging). Especially, it is useful as a reception only birdcage coil.
[0002]
[Description of the Prior Art] Drawing 7 is the block diagram showing an example of the conventional birdcage coil for MRI. This birdcage coil 500 for MRI interposes many elements E between the 1st ring R51 and the 2nd ring R2, and comes to interpose Capacitor C, respectively between the nodes of the plurality of the 1st ring R51 of the above, and the aforementioned element E, and between the nodes of the plurality of the 2nd ring R2 of the above, and the aforementioned element E. and the capacitor C interposed in the 1st ring R51 of the above -- respectively -- being alike -- a parallel resonating frequency with Capacitor C -- the frequency of RF pulse for MRI -- ****** -- the series circuit of the inductor L which defined the inductance like, and two diodes D (a varistor is sufficient) by which the antiparallel connection was carried out is connected in parallel Therefore, at the time of transmission of RF pulse for MRI from another transmitting coil (for example, body coil), Diode D turns on with big induced electromotive force, and parallel resonance can be carried out, and the aforementioned capacitor C and Inductor L can turn off the function as a coil, and can carry out decoupling (Decoupling) to another transmitting coil. On the other hand, at the time of reception of an NMR signal, since induced electromotive force is very feeble, Diode D does not turn on and it functions as a coil (receiver coil). In addition, the basic composition of the above-mentioned birdcage coil 500 for MRI is indicated by the open official report concerning Japanese Patent Application No. No. 282477 [one to]. Generally this kind of decoupling circuit is called passive (Passive; passivity) type decoupling circuit.
[0003] Drawing 8 is the block diagram showing another example of the conventional birdcage coil. This birdcage coil 600 interposes many elements E between the 1st ring R51 and the 2nd ring R2, and comes to interpose Capacitor C, respectively between the nodes of the plurality of the 1st ring R51 of the above, and the aforementioned element E, and between the nodes of the plurality of the 2nd ring R2 of the above, and the aforementioned element E. And RF pulse transmission medium K51 for MRI for supplying electric power in RF pulse for MRI is derived from one ends of the capacitors C interposed in the 1st ring R51 of the above (the core wire and the outer conductor of RF pulse transmission medium K51 for MRI are connected to the ends of Capacitor C). furthermore, the capacitor C interposed in the 2nd ring R2 of the above -- respectively -- being alike -- the frequency of an NMR signal, and abbreviation -- LC circuit which can form a parallel resonant circuit with the same parallel resonating frequency is connected in parallel That is, the end of each series circuit is connected to the ends of the aforementioned capacitor C, respectively, using two of the series circuits of an inductor L52 and a capacitor C52 as 1 set, and the other end of each series circuit is connected through Diode D.
[0004] At the time of transmission of RF pulse for MRI, a reverse voltage (namely, anode voltage Va< cathode voltage Vk) is applied to the aforementioned diode D through the bias cable B1 and B-2, Diode D is turned off, and the aforementioned series circuit is separated electrically. Consequently, it can operate as a transmitting coil. On the other hand, at the time of reception of the NMR signal by another receiver coil (for example, Sir face coil), forward voltage (namely, anode voltage Va> cathode voltage Vk) is applied to the aforementioned diode D through the bias cable B1 and B-2, Diode D is turned on, and a parallel resonant circuit is formed. Consequently, the function as a coil can be turned off and decoupling can be carried out to another receiver coil. In addition, generally this kind of decoupling circuit is called active (Active; activity) type decoupling circuit.
[0005] Drawing 9 is the typical external view showing still more nearly another example of the conventional birdcage coil. This birdcage coil 700 interposes many elements Ea and Eb and -- between the 1st ring R61 and the 2nd ring R62, and is the composition of the aforementioned elements Ea and Eb and -- which interposed switching circuits Sa and Sb and -- in the center.
[0006] A switching circuit Sa connects the end of capacitor C61a, and the end of capacitor C62a to

the front end side of Element Ea, as shown in drawing 10 . The other end of capacitor C61a and the anode of diode D61a are connected. The other end of capacitor C62a and the cathode of diode D62a are connected. The end of capacitor C63a is connected with the cathode of diode D61a, and the anode of diode D62a. Connect the other end of capacitor C63a to the back end side of Element Ea, and the anode of diode D61a is used as one bias terminal. The end of the blocking circuit which consists of a parallel circuit of capacitor C64a and Coil La is connected to the cathode of diode D62a, and let the other end of the blocking circuit be another bias terminal. Other switching circuits Sb and -- are also the same composition as the above-mentioned switching circuit Sa.
[0007] And the bias terminal by the side of the blocking circuit of a switching circuit Sa is connected to the control line beta from the outside, and the bias terminal of the side which does not have the blocking circuit of a switching circuit Sa is connected to the bias terminal by the side of the blocking circuit of a switching circuit Sb. Like the following, each switching circuit is connected in series and another control line alpha is drawn from the last switching circuit.
[0008] These switching circuits Sa and Sb and -- are turned on when impressing negative voltage to the control line alpha at positive and the control line beta. Moreover, when impressing positive voltage to the control line alpha at negative and the control line beta, it comes to be turned off. That is, the function of the above-mentioned birdcage coil 700 for MRI can be electrically turned on and off. In addition, the basic composition of the above-mentioned birdcage coil 700 is indicated by JP,4-50006,U.
[0009]
[Problem(s) to be Solved by the Invention] With the above-mentioned conventional birdcage coil 500 for MRI, at the time of transmission of RF pulse for MRI, since Diode D turns on autonomously with big induced electromotive force and decoupling is carried out to a transmitting coil, operation is self-conclusion-like and there is an advantage which can make composition comparatively simple. However, since the induced electromotive force at the time of transmission of RF pulse for MRI fully needs to be large in order to collateralize certainty of operation, there is a trouble with difficult application in a small birdcage coil.
[0010] Moreover, with the above-mentioned conventional birdcage coil 600 for MRI, since the function of a coil is turned on and off from the exterior through the bias cable B1 and B-2, even if it is a small configuration, there is an advantage which can ensure turning on and off. However, apart from RF pulse transmission medium K51 for MRI, since it is necessary to derive many bias cables S1 and S2 (to refer to drawing 8), there is a trouble that composition is complicated or a coil property deteriorates.
[0011] Furthermore, with the above-mentioned conventional birdcage coil 700, since switching circuits Sa and Sb and -- are interposed in Elements Ea and Eb and the center of -- and the control lines alpha and beta are derived from two of these switching circuits, the same trouble as the above-mentioned conventional birdcage coil 600 for MRI is produced. Moreover, since seven circuit elements (two diode D61a, D62a, four capacitor C61a, C62a and C63a, C64a, and Coils La) are used, there is a trouble which circuitry complicates in a switching circuit Sa.
[0012] Then, the purpose of this invention can perform decoupling with other coils certainly, and does not spoil an original coil property, but, moreover, circuitry is to offer the easy birdcage coil for MRI in comparison.
[0013]
[Means for Solving the Problem] In the birdcage coil for MRI with which this invention comes to interpose two or more elements between the 1st ring and the 2nd ring in the 1st viewpoint The capacitor series circuit of the 1st ring of the above, the 1st capacitor interposed in one between the nodes of the plurality of the aforementioned element, and the 2nd capacitor, parallel connection is carried out to the 1st capacitor of the above -- having -- and a parallel resonating frequency with the 1st capacitor -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- with the series circuit of the 1st inductor which defined the inductance like, and the 1st diode it interposes between the nodes of everything but the 1st ring of the above, and the aforementioned element, respectively -- having -- and the aforementioned capacitor series circuit and abbreviation -- with two or more 3rd capacitors with the same capacity parallel connection is carried out to these 3rd capacitors -- having -- and a parallel resonating frequency with the 3rd capacitor -- the frequency of RF pulse for MRI, or

an NMR signal -- ****** -- with the series circuit of the 2nd inductor which defined the inductance like and the 1st diode of the above, and the 2nd diode of the same direction The 2nd ring of the above, and two or more 4th capacitors interposed between the nodes of the aforementioned element, respectively, While supplying the forward voltage/reverse voltage which is drawn in the ends shell exterior of the 2nd capacitor of the above, and turns on / turns off the 1st diode of the above, and the 2nd diode The birdcage coil for MRI characterized by providing the signal-transmission cable for taking out an NMR signal or supplying electric power in RF pulse for MRI is offered.
[0014] In the birdcage coil for MRI with which this invention comes to interpose two or more elements between the 1st ring and the 2nd ring in the 2nd viewpoint The 1st ring of the above, and two or more capacitors for the 1st direct-current cut interposed alternately between the nodes of the plurality of the aforementioned element, The 2nd ring of the above, and two or more capacitors for the 2nd direct-current cut by which the aforementioned capacitor for the 1st direct-current cut was interposed alternately alternately between the nodes of the plurality of the aforementioned element, The capacitor series circuit of the 3rd capacitor interposed in the one center of abbreviation of two or more aforementioned elements, and the 4th capacitor, parallel connection is carried out to the 3rd capacitor of the above -- having -- and a parallel resonating frequency with the 3rd capacitor -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- with the series circuit of the 1st inductor which defined the inductance like, and the 1st diode it interposes in the center of abbreviation of the element in every other one, respectively from the element which adjoined the element in which the aforementioned capacitor series circuit was prepared, and them -- having -- and the aforementioned capacitor series circuit and abbreviation -- with two or more 5th capacitors with the same capacity parallel connection is carried out to these 5th capacitors -- having -- and a parallel resonating frequency with the 5th capacitor -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- the 2nd inductor which defined the inductance like, and the 1st diode of the above with the series circuit of the 2nd diode of a retrose it interposes in the center of abbreviation of other elements, respectively -- having -- and the aforementioned capacitor series circuit and abbreviation -- with two or more 6th capacitors with the same capacity parallel connection is carried out to these 6th capacitors -- having -- and a parallel resonating frequency with the 6th capacitor -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- with the series circuit of the 3rd inductor which defined the inductance like and the 1st diode of the above, and the 3rd diode of the same direction While supplying the forward voltage/reverse voltage which is drawn in the ends shell exterior of the 4th capacitor of the above, and turns on / turns off the above 1st, the 2nd, and the 3rd diode The birdcage coil for MRI characterized by providing the signal-transmission cable for taking out an NMR signal or supplying electric power in RF pulse for MRI is offered.
[0015]
[Function] the 1st capacitor and the 3rd capacitor which were interposed in the 1st ring with the birdcage coil for MRI of the 1st viewpoint of the above -- a parallel resonating frequency -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- the series circuit of the 1st which defined the inductance like, the 2nd inductor and the 1st, and the 2nd diode (same direction) is connected in parallel Therefore, by applying the forward voltage which turns on the 1st diode and the 2nd diode through a signal-transmission cable, along with the 1st ring, two or more parallel resonant circuits (high impedance state) are formed, and the function as a coil can be turned off. Moreover, by applying the reverse voltage which turns off the 1st diode and the 2nd diode through a signal-transmission cable, the series circuit of the 1st, the 2nd inductor and the 1st, and the 2nd diode is separated electrically, and it can operate as a high path type birdcage coil. As mentioned above, since transmission of an original transmission signal (an NMR signal or RF pulse for MRI) and supply of the direct current voltage for turning the function as a coil on and off are made to use also [cable / signal-transmission], circuitry can be simplified and it is not necessary to spoil an original coil property. Moreover, since an active type decoupling circuit is used, decoupling with other coils can be performed certainly.
[0016] With the birdcage coil for MRI of the 2nd viewpoint of the above, two or more capacitors for the 1st direct-current cut are interposed alternately between the nodes of the plurality of the 1st ring and an element, and the capacitor for the 1st direct-current cut interposes the capacitor for the 2nd direct-current cut alternately between the nodes of the 2nd ring and two or more elements. one

[and] of two or more of the elements -- the capacitor series circuit of the 3rd capacitor and the 4th capacitor -- interposing -- the 3rd capacitor -- a parallel resonating frequency -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- the series circuit of the 1st inductor which defined the inductance like, and the 1st diode is connected in parallel furthermore -- the center of abbreviation of other elements -- the aforementioned capacitor series circuit and abbreviation -- the 5th and the 6th capacitor with the same capacity -- interposing -- them 5th and the 6th capacitor -- a parallel resonating frequency -- the frequency of RF pulse for MRI, or an NMR signal -- ****** -- the series circuit of the 2nd which defined the inductance like, the 3rd inductor and the 2nd, and the 3rd diode (the sense is reverse for every adjacent element) is connected in parallel Therefore, by applying the forward voltage which turns on the 1st, the 2nd, and the 3rd diode through a signal-transmission cable, a parallel resonant circuit (high impedance state) is formed in each element, and the function as a coil can be turned off. Moreover, by applying the reverse voltage which turns off the 1st, the 2nd, and the 3rd diode through a signal-transmission cable, the series circuit of the 1st, the 2nd, the 3rd inductor and the 1st, the 2nd, and the 3rd diode is separated electrically, and it can operate as a low-pass type birdcage coil. As mentioned above, since transmission of an original transmission signal (an NMR signal or RF pulse for MRI) and supply of the direct current voltage for turning the function as a coil on and off are made to use also [cable / signal-transmission], circuitry can be simplified and it is not necessary to spoil an original coil property. Moreover, since an active type decoupling circuit is used, decoupling with other coils can be performed certainly.

[0017]

[Example] Hereafter, the example shown in drawing explains this invention to a detail further. In addition, thereby, this invention is not limited.

[0018] - 1st example- drawing 1 is the block diagram showing the birdcage coil for MRI of the 1st example of this invention. On account of explanation, about a capacitor and an inductance, as long as capacity and an inductance are equal, the same reference mark is used. This birdcage coil 100 for MRI interposes many elements E between the 1st ring R1 and the 2nd ring R2, and comes to interpose the capacitor series circuit of the 1st capacitor C1 and the 2nd capacitor C2 in one between the nodes of the plurality of the 1st ring R1 of the above, and the aforementioned element E. and -- the 1st capacitor C1 of the above -- a parallel resonating frequency with the 1st capacitor C1 -- RF pulse for MRI -- ****** -- the series circuit of the 1st inductor L1 which defined the inductance like, and the 1st diode D1 is connected in parallel Moreover, the 3rd capacitor C is interposed between the nodes of everything but the 1st ring R1 of the above, and the aforementioned element E. The capacity of the 3rd capacitor C of the above is the same as the capacity of the capacitor C concerning the above-mentioned conventional birdcage coil 500 (refer to drawing 7) for MRI. In addition, the capacity of the aforementioned capacitor series circuit is equal to the capacity of Capacitor C (that is, 1/C=1/C1+1 / C2 is filled). and -- the 3rd capacitor C of the above -- a parallel resonating frequency with the 3rd capacitor C -- the frequency of RF pulse for MRI -- ****** -- the series circuit of the 2nd inductor L which defined the inductance like and the 1st diode D1 of the above, and the 2nd diode D2 of the same direction is connected in parallel Furthermore, between the nodes of the plurality of the 2nd ring R2 of the above, and the aforementioned element E, the 4th capacitor C is interposed, respectively. The NMR signal-transmission cable K1 for taking out an NMR signal is derived from the ends of the 2nd capacitor C2 of the above further again (the core wire and the outer conductor of the NMR signal-transmission cable K1 are connected to the ends of the 2nd capacitor C2). In addition, in addition to an original transmission signal, positive or negative direct current voltage may be superimposed on the aforementioned NMR signal-transmission cable K1.

[0019] Now, at the time of transmission of RF pulse for MRI from another transmitting coil, positive direct current voltage is superimposed on the NMR signal-transmission cable K1 (what is necessary is just to only supply direct current voltage, since there is no original transmission signal in this case). Then, the 1st diode D1 and the 2nd diode D2 turn on, and a parallel resonant circuit is formed. The substantial circuitry at this time is shown in drawing 2 (a dotted line shows direct-current mesh-currents i which flows through the 1st ring R1 and Inductor L). Consequently, the 1st ring R1 will be in a high impedance state to RF pulse for MRI, the function as a coil is turned off, and decoupling can be carried out to another transmitting coil.

[0020] On the other hand, at the time of reception of an NMR signal, negative direct current voltage

is superimposed on the NMR signal-transmission cable K1. Then, since the 1st diode D1 and the 2nd diode D2 turn off, it reaches 1st diode D1 and the series circuit of the 1st inductor L and the series circuit of the 2nd inductor L2 and the 2nd diode D2 are separated electrically. The substantial circuitry at this time is shown in drawing 3 . Consequently, it can operate as a high path type birdcage coil for reception (negative direct current voltage is overlapped on an NMR signal in this case).

[0021] Since transmission of an original transmission signal, i.e., an NMR signal, and supply of the direct current voltage for turning the function as a coil on and off are made to use also [cable / NMR signal-transmission / K1] according to the birdcage coil 100 for MRI of the 1st example of the above, circuitry can be simplified and it is not necessary to spoil an original coil property. Moreover, since an active type decoupling circuit is used, decoupling with other coils can be performed certainly.

[0022] - 2nd example- drawing 4 is the block diagram showing the birdcage coil for MRI of the 2nd example of this invention. On account of explanation, about a capacitor and an inductance, as long as capacity and an inductance are equal, the same reference mark is used. This birdcage coil 200 for MRI interposes many elements E between the 1st ring R11 and the 2nd ring R12. Two or more capacitors Cx for the 1st direct-current cut (in order to make a RF-impedance small, it is large capacity to general) are interposed alternately between the nodes of the plurality of the 1st ring R11 of the above, and the aforementioned element E. The aforementioned capacitor Cx for the 1st direct-current cut comes to interpose the capacitor Cx for the 2nd direct-current cut alternately alternately between the nodes of the plurality of the 2nd ring R12 of the above, and the aforementioned element E. moreover -- one center of abbreviation of the aforementioned element E -- the capacitor series circuit of the 3rd capacitor calcium and the 4th capacitor Cb -- interposing -- the 3rd capacitor calcium of the above -- parallel resonance capacity with the 3rd capacitor calcium -- the frequency of RF pulse for MRI -- ****** -- the series circuit of the 1st inductor La which defined the inductance like, and the 1st diode D1 is connected in parallel

[0023] the element which adjoins the element in which the aforementioned capacitor series circuit was interposed -- and -- and -- the center of abbreviation of the element in every other one -- the aforementioned capacitor series circuit and abbreviation -- the 5th capacitor C with the same capacity is interposed (that is, 1/C=1/calcium+1/Cb is filled) these 5th capacitors C -- parallel resonance capacity with the 5th capacitor C -- the frequency of RF pulse for MRI -- ****** -- the 2nd inductor Lb which defined the inductance like, and the 1st diode D1 of the above connect the series circuit of the 2nd diode D2 of a retrose in parallel moreover -- the center of abbreviation of other elements (element in every other [in which the aforementioned capacitor series circuit was prepared / an element to] one) -- the aforementioned capacitor series circuit and abbreviation -- the 6th capacitor C with the same capacity is interposed these 6th capacitors C -- parallel resonance capacity with the 6th capacitor C -- the frequency of RF pulse for MRI -- ****** -- the series circuit of the 3rd inductor Lb which defined the inductance like and the 1st diode D1 of the above, and the 3rd diode D3 of the same direction is connected in parallel Furthermore, the NMR signal-transmission cable K1 for taking out an NMR signal is derived from the ends of the 4th capacitor Cb of the above (the core wire and the outer conductor of the NMR signal-transmission cable K1 are connected to the ends of the 4th capacitor Cb). In addition, in addition to an original transmission signal, positive or negative direct current voltage may be superimposed on the aforementioned NMR signal-transmission cable K1.

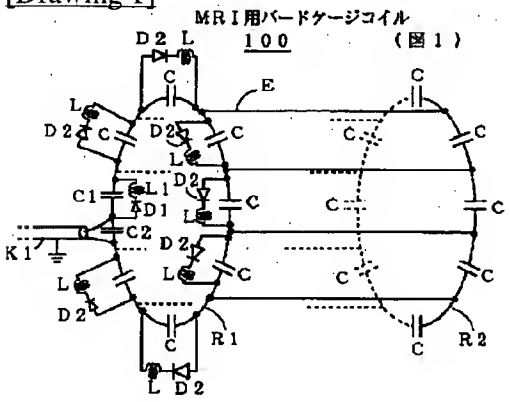
[0024] Now, at the time of transmission of RF pulse for MRI from another transmitting coil, positive direct current voltage is superimposed on the NMR signal-transmission cable K1 (what is necessary is just to only supply direct current voltage, since there is no original transmission signal in this case). Then, the 1st, the 2nd, and the 3rd diode D1, D2, and D3 turn on, and a parallel resonant circuit is formed. The substantial circuitry at this time is shown in drawing 5 (a dotted line shows direct-current mesh-currents i which flows through the 1st, the 2nd ring R11 and R12, and Inductors La and Lb). Consequently, each element E will be in a high impedance state to RF pulse for MRI, the function as a coil is turned off, and decoupling can be carried out to another transmitting coil.

[0025] On the other hand, at the time of reception of an NMR signal, negative direct current voltage is superimposed on the NMR signal-transmission cable K1. Then, since the 1st, the 2nd, and the 3rd

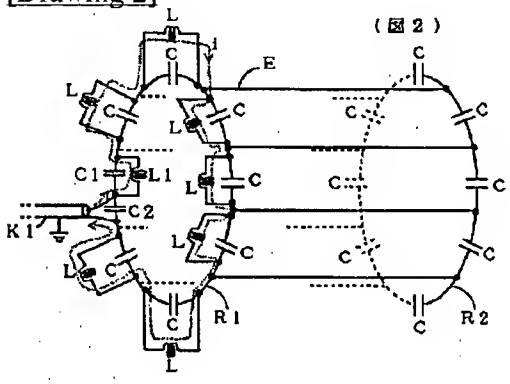
diode D1, D2, and D3 turn off, the series circuit of the 1st, the 2nd, the 3rd inductor La, Lb, and Lc and the 1st, the 2nd, and the 3rd diode D1, D2, and D3 is separated electrically. The substantial circuitry at this time is shown in drawing 6 . Consequently, it can operate as a low-pass type birdcage coil for reception (negative direct current voltage is overlapped on an NMR signal in this case).
[0026] According to the birdcage coil 200 for MRI of the 2nd example of the above, the same effect as the 1st example of the above can be acquired also about the low-pass type birdcage coil for MRI.
[0027] In addition, in the above 1st and the 2nd example, although the birdcage coil for MRI for reception was explained, it is applicable also like the birdcage coil for MRI for transmission. In this case, as diode, in order to prevent the breakage at the time of electric supply of RF pulse for MRI, what has power-proof large enough is used.
[0028]
[Effect of the Invention] It comes to be able to carry out decoupling certainly with other coils also in the case of a small configuration at the time of transmission of RF pulse for MRI, or reception of an NMR signal according to the birdcage coil for MRI of this invention. Moreover, it becomes comparatively easy composition. Therefore, homogeneous high RF magnetic field is formed, or it becomes useful obtaining high SNR (Signal To Noise Ratio; signal-to-noise ratio).

DRAWINGS

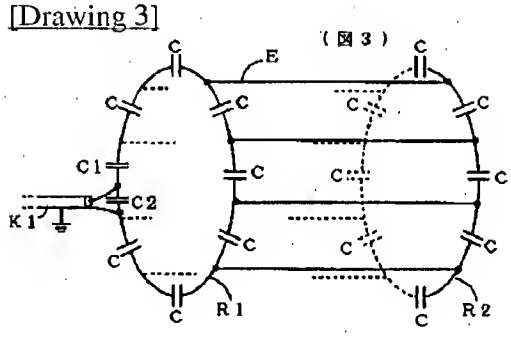
[Drawing 1]



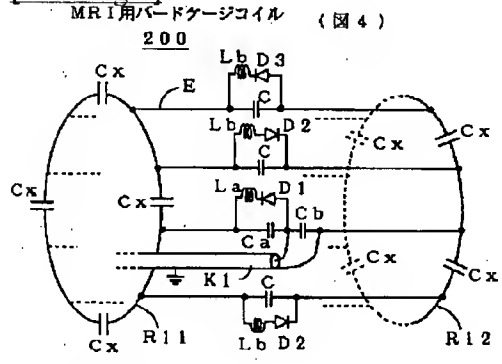
[Drawing 2]



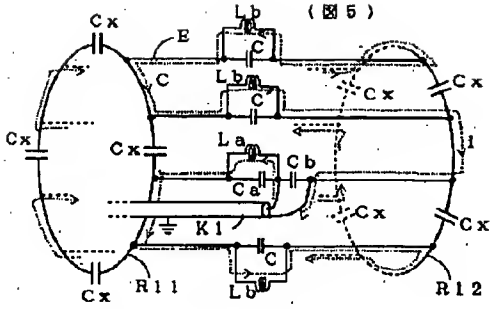
[Drawing 3]



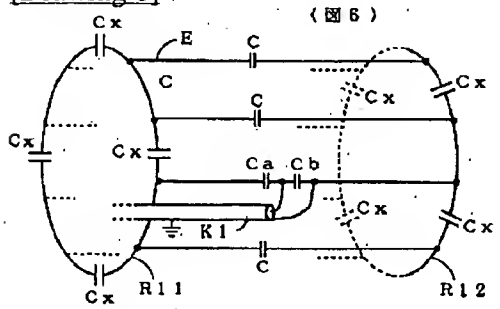
[Drawing 4]



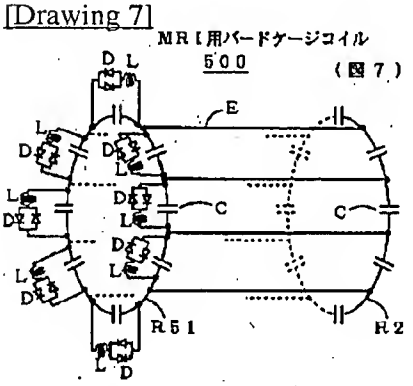
[Drawing 5]



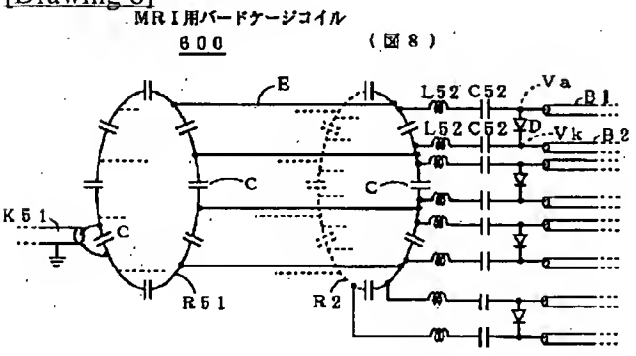
[Drawing 6]



[Drawing 7]



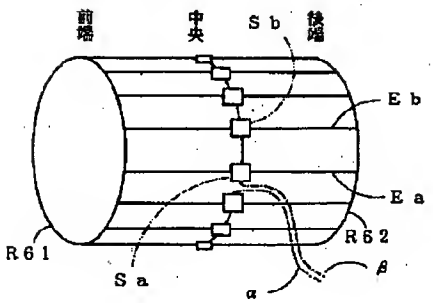
[Drawing 8]



[Drawing 9]

MRI用バードケージコイル （図９）

700



[Drawing 10]